



TOHA
Science

Regenerative Agriculture Claim Forecast

February 2022

Regenerative Agriculture Claim Forecast

The purpose of this document is to outline potential Claims within the Regenerative Agriculture market category for the Toha Network, based on the existing Regenerative Agriculture Catalyst Framework. A Claim is a unique assertion that an outcome has occurred, backed up by the Measurements that are contained in the Claim's dataset. These Measurements derive from one or more Pledges to conduct activities that are expected to have an environmental or social impact (measurable, positive outcome). Purchasers of Claims obtain access to (but not ownership of) the Measurements attached to a particular Claim.

Claims are outlined in this document at a high level, as the specific data included will differ depending on the needs of purchasers. They include both Claims that align with existing market standards, and Claims that are novel but that we believe will be valued by external purchasers. All of them are based on outcomes which existing scientific knowledge links to specific activities and/or categories of activities.

Using this document should support the development of Claims on the Toha Network by multiple parties. It also helps identify knowledge gaps (see the Knowledge Gaps document) which scientific research is needed to bridge, in order for Claims to be made in future on a sound scientific basis.

Authorship and Citation

This review was researched and written by Dr Lucy C. Stewart and reviewed internally by Shaun Hendy and Erin Crampton. We thank our colleagues at Toha for their constructive feedback.

It may be cited as: Toha Science. 2022. *Regenerative Agriculture Claim Forecast*. Wellington: Toha Foundry Ltd.

Disclaimer

This Claim Forecast is intended to provide a snapshot of the research on this topic, as of July 2021, for those wishing to familiarise themselves with the current state of the research. It is not intended as a recommendation to adopt any of the practices described therein and we provide no assurance nor opinion on effective results of the adoption of those practices. Whilst every effort has been made to ensure this is a comprehensive review of the available literature on this subject, including through the use of expert peer review, there may be areas or publications that we have omitted.

Copyright

© 2022 Toha Foundry Limited

Unless otherwise stated, this copyright work is licenced for re-use under a [Creative Commons Attribution 4.0 International Licence](#). You are free to copy, distribute, and adapt the work, as long as you attribute it to Toha Foundry Ltd and abide by the other licence terms. The following attribution statement can be used:

Source: Toha Foundry Ltd, licensed for re-use under the Creative Commons Attribution 4.0 International Licence.

Published in February 2022 by
Toha Foundry Ltd
PO Box 3002
Kaiti
Gisborne, 4010

ISBN: 978-0-473-61913-8
Publication number: TS0003

This document and the rest of the science roadmap it belongs to are available at:
www.tohascience.org

Contents

| | |
|---|-----------|
| What is a Claim? | 4 |
| What is this document for? | 4 |
| Current Impact Goals from the Catalyst Framework | 4 |
| External Claim Opportunities | 5 |
| A Worked Example of Bundling: SAFI | 5 |
| Prioritising Future Claims | 6 |
| Claim Outlines in this Forecast | 7 |
| Current possible Claims - summary table | 8 |
| Improved Riparian Planting Claim | 9 |
| Drought and Flood Resilience Claim | 10 |
| Pasture Biodiversity & Soil Health Claim | 11 |
| Pollution Reduction Claim | 12 |
| Climate Risk Claim | 13 |
| Limited Nitrogen Input Claim | 13 |
| Emission Reduction Claim | 14 |
| Erosion Risk Reduction Claim | 14 |
| Circular Farm Economy Claim | 14 |
| Reduced Runoff Claim | 15 |
| Soil Carbon Maintenance Claim | 15 |
| Farm Financial Resilience Claim | 15 |
| Stock Reduction Claim | 15 |
| Future Claims - summary table | 16 |
| Improved Freshwater Quality Claim | 17 |
| Increased Above-Ground Carbon Claim | 18 |
| Increased Soil Carbon Claim | 18 |
| Protecting the Water Cycle Claim | 19 |
| Sustainable Agriculture Finance Initiative Claim | 19 |
| Regenerative Organic Standard Claim | 19 |
| Claim gaps | 20 |
| Bibliography | 21 |

What is a Claim?

Within the Toha ecosystem, a Claim is a unique assertion that an outcome has occurred, backed up by the measurements that are contained in the Claim’s dataset. These measurements derive from one or more Pledges to conduct activities that are expected to have an environmental or social impact (measurable, positive outcome). Purchasers of Claims obtain access to (but not ownership of) the measurements attached to a particular Claim. Claims may also contain processed data that is derived from Pledge measurements, depending on the kind of Claim being made - for example, a Claim about carbon sequestration would be derived from data about soil or vegetation.

Claims can take a wide variety of forms. The most fundamental Claim will be that an impact has occurred as a result of activities undertaken through a Pledge or Pledges. But it will also be possible to make a Claim that an activity has been undertaken, or that verifiable data has been collected. The only real limits on Claims are the need for them to be unique and the presence of purchasers for them.

Note especially that the requirement is that the Claim is unique, not the measurements used to make it. For example, if a dataset about trees planted is used to make a Claim which is sold as a carbon offset, it cannot be used again for that purpose. But the same dataset could be used as part of a Claim about biodiversity improvement on that piece of land, or erosion mitigation, or local employment, or any number of other things. Additionally, this document (and this Roadmap) focuses on what we believe are the most immediately achievable and valuable Claims from regenerative agriculture Pledges, but does not seek to value them relative to each other.

What is this document for?

This document lays out a set of potential Claims that could be made based on Pledges which use the Regenerative Agriculture Catalyst Framework as a foundation, from a scientific and data-driven perspective.

It is not intended to set boundaries on the kinds of Claims which may be created in this space, but as a starting point for developing Claims.

It is also not intended to create ‘pre-made’ Claims which can be instantiated immediately. Claim developers will still have to consider the specific measurements which Pledge Holders have made, the market into which the Claim will be offered for purchase, any necessary processing and/or analysis of data, and any external datasets that may be necessary to incorporate (e.g. land or weather data).

Current Impact Goals from the Catalyst Framework

Impact Goals, within a Catalyst Framework, are the highest-scale impacts that Pledge Holders seek to achieve by making Pledges using that framework. They are not usually, in themselves, specific Claims. Table 1 below lists the current Impact Goals found in the Regenerative Agriculture Catalyst Framework. Impact Goals highlighted in red are planned but not yet implemented in the Framework.

| | |
|--|--|
| Increase in Animal Health | Decrease in Air Pollution |
| Increase in Produce Quality | Decrease in Non-Recyclable Waste |
| Increase in Soil Health | Maintain or Increase Farm Business Profitability |
| Increase in below and above ground Carbon Stocks | Increase in Financial Resilience |
| Decrease in Total Greenhouse Gas Emissions | Increase in Community Health & Wellbeing |
| Increase in Drought and Flood Resilience | Increase in Ecological Resilience |
| Increase in Freshwater Quality | Improvement in Animal Welfare |
| Limited Nitrogen Input | Improvement in Worker Wellbeing |
| Increase in Groundwater Health | |

Table 1: Current Impact Goals

Impact Goals are not necessarily intended to be Claims in and of themselves. Instead, they indicate the intentions of a Pledge. The specifics of Claims will depend on the data and scope that are attractive to and/or required by purchasers.

For instance, ‘Decrease in Air Pollution’ is an Impact Goal in the Catalyst Framework, but purchasers may be interested simply in purchasing Claims that burn-offs have been reduced (a Milestone which contributes to this Impact Goal) - or they may wish to purchase a ‘Pollution Reduction Claim’ which includes data from multiple Impact Goals that are linked to reductions in environmental pollution.

External Claim Opportunities

Some Claims will align with standards or offers which are set by external organisations prior to the development of a Pledge. In this case, a Pledge Template and measurement framework may be designed to support external Claim opportunities (among other goals). Here, we outline several existing standards which the Regenerative Agriculture Catalyst Framework and Pledge Templates and measurement frameworks based on it may support.

It is important to note that for an external standard, a single Claim may not encompass everything covered by the standard. In this case, it can be met by putting together multiple Claims (Figure 1). This may also be the case for standards set by Toha or a venture, where individual Pledge Holders work towards meeting the entire standard by making individual Claims as they grow their Pledges and add Milestone Agreements.

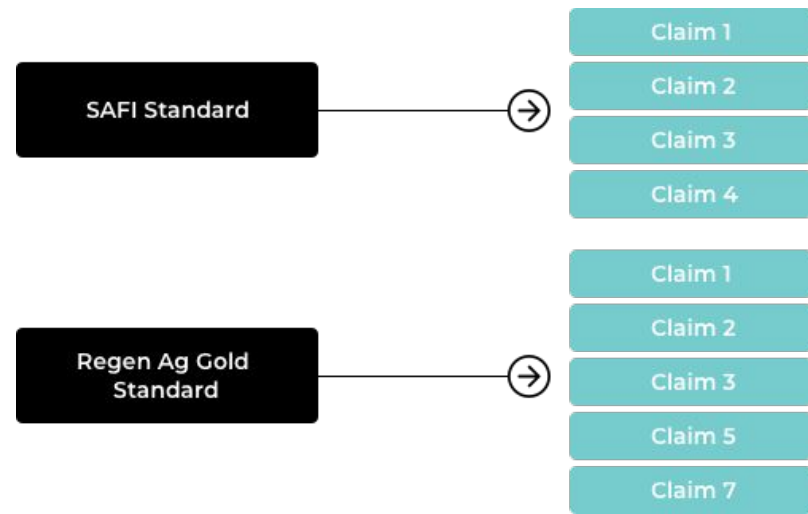


Figure 1: Bundling Claims to meet market standards

A Worked Example of Bundling: SAFI

The Sustainable Agriculture Finance Initiative standard seeks to emulate the EU Taxonomy for Sustainable Investment by outlining the requirements for agricultural practices to be considered for inclusion in climate-friendly or 'green' bonds. Within the proposed SAFI standard, an investment must show that it is making a 'substantial contribution' in one of the six key areas of the standard, do no harm in the other five, and also meet minimum standards in three related social areas. Figure 2 shows how a farmer with a regenerative agriculture Pledge built under the Catalyst Framework might bundle data from different Milestones (into one Claim, or multiple Claims per part of the standard) to meet the SAFI standard.

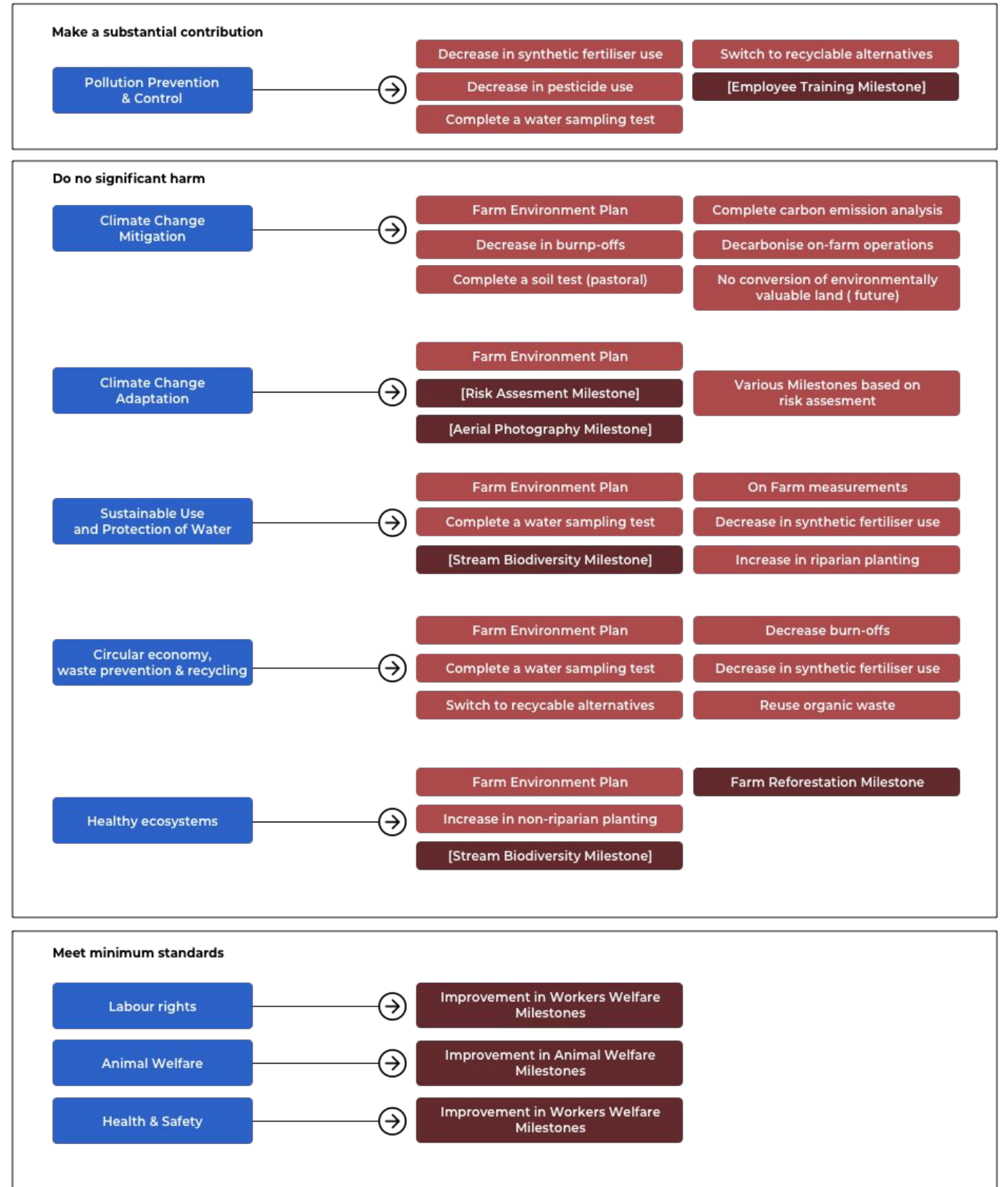


Figure 2: Bundling data from Milestones (not yet identified as Claims) to meet the total SAFI standard

Prioritising Future Claims

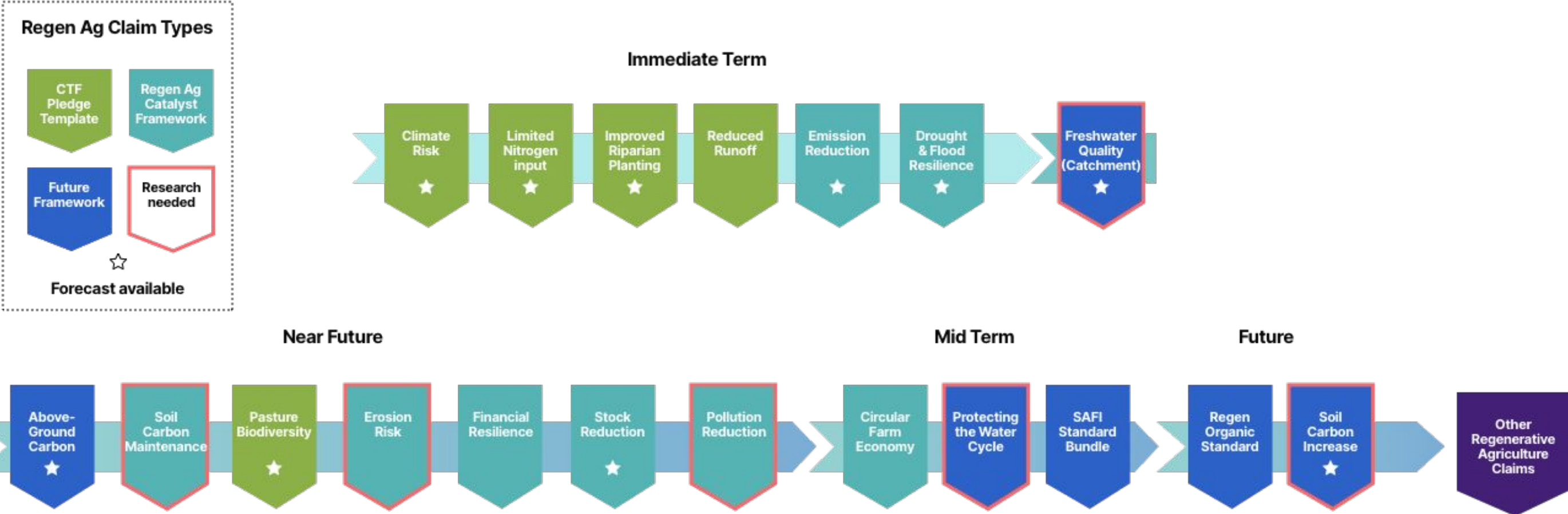


Figure 3: The proposed priority order of Claims in this document
 This is based on the availability of measurements to support these Claims in an existing Pledge Template and/or Catalyst Frameworks, the existence of 'gaps' (see below), and our perception of current markets.

Claim Outlines in this Forecast

The term “Claim” covers a number of linked products, which can be thought of as providing different windows onto the total set of information associated with an individual Claim. This Forecast, for each Claim, will only outline the pieces of information which give an understanding of the scientific basis for proposed Claims and the kind of data needed to support them. A full Claim will include a range of other information for market, financial, and record-keeping purposes. For this first forecast, we have selected a limited number of Claims to outline; others are described in order to distinguish them as distinct Claims, but not outlined in their specifics.

| | |
|------------------------------|---|
| Claim title | Name of the specific Claim (e.g. ‘Climate Risk Reduction Claim’). |
| Claim description | <100w description of what is being claimed and on what grounds. |
| Activities data | List of any Pledge activity data required for the Claim |
| Outcome data | List of any outcome data required for the Claim |
| Metadata | List of any metadata required for the Claim |
| External data | List of any external dataset data required for the Claim |
| Analysis requirements | Outline of analysis requirements to create the Claim (processes, software, third-party analysis) |
| Scale | Timeframe and whether Claim is expected to require data from more than one Pledge (e.g. Claim based on multiple Pledges, after five years of data collection) |
| Target purchaser | General description of potential purchasing audience (e.g. banks, insurance companies, local government, offsetters) |
| Claim type | Is this likely to be a recurring or one-off Claim? |
| Claim potential | Size of market and numbers that could be reduced - e.g., will reduce X% of total kg N put on NZ soils per year |
| Associated Claims | Any Claims which are excluded by this Claim, or which this Claim will be bundled with to meet a larger standard |
| Claim context | Scientific context and backing for this Claim |

Current possible Claims - summary table

Claims with an asterisk are supported by the initial Calm the Farm Pledge Template. Claims in **bold text** are fully outlined.

| Claim | Description | Scale | Purchaser(s) | Can be bundled towards... |
|---|--|---|-------------------------------|---|
| Improved Riparian Planting Claim* | Claim that Pledge Holder has carried out riparian planting to maximum recommended levels, beyond regulatory requirements. | Single Pledge, 5-15 years | National government | Above-ground carbon claims |
| Drought and Flood Resilience Claim | Claim that Pledge Holder has improved water retention in soils, making farm more resilient to both drought and flood conditions | Single Pledge, 2-5 years | Banks, insurers | Protecting the Water Cycle |
| Pasture Biodiversity Claim* | Claim that Pledge Holder has increased the biodiversity of farm pastures, above and below ground. | Single Pledge, 2-10 years | Biodiversity credit markets | SAFI, Regenerative Organic Standard |
| Pollution Reduction Claim | Claim that Pledge Holder has reduced farm pollution overall (in water, air, and soil). | Single Pledge, 1-5 years | Local government | SAFI, Regenerative Organic Standard |
| Climate Risk Claim* | Claim that Pledge Holder is altering spending to focus on climate mitigation + adaptation, while maintaining productivity & animal health | Single Pledge, immediate | Banks | SAFI, TCFD |
| Limited Nitrogen Input Claim* | Claim that Pledge Holder has reduced total nitrogen inputs (above natural fixation) and eliminated synthetic nitrogen inputs. | Single Pledge, immediate | Local government | SAFI |
| Emission Reduction Claim | Claim that Pledge Holder is reducing their overall emissions | Single Pledge, immediate | Carbon market(s) | N/A |
| Erosion Risk Reduction Claim | Claim that Pledge Holder has improved soil health and lowered the risk of erosion. | Single or multiple Pledge(s), 2-5 years | Banks, insurers | SAFI, Regenerative Organic Standard |
| Circular Farm Economy Claim | Claim that Pledge Holder is tracking and minimising farm waste streams, and recycling where possible. | Single Pledge, 1-5 years | Local government | SAFI |
| Reduced Runoff Claim* | Claim that Pledge Holder has reduced runoff of nutrients and soil into local freshwater. A precursor to 'Improvement in Freshwater Quality' catchment-level Claim. | Single Pledge, 2+ years | Local and national government | Improvement in Freshwater Quality, Drought and Flood Resilience |
| Stock Reduction Claim* | Claim that Pledge Holder has reduced their stocking rate | Single Pledge, 2 years + | Government, banks(?) | N/A |
| Soil Carbon Maintenance Claim | Claim that Pledge Holder is acting to prevent carbon loss from soil | Single Pledge, 2 years+ | Voluntary carbon market(s) | N/A |
| Farm Financial Resilience Claim | Claim that Pledge Holder has made farm more financially resilient while maintaining profitability. | Single Pledge, 3-10 years | Banks | N/A |

Improved Riparian Planting Claim

| | |
|------------------------------|--|
| Claim title | Improved Riparian Planting Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has carried out riparian planting to maximum recommended levels, beyond current regulatory requirements. As a recurring Claim, it will provide certainty that riparian planting is persisting in the long term and providing the intended benefits.</p> <p>The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none"> 1. Metadata on farm size and waterways 2. Riparian planting data 3. Riparian planting persistence data |
| Activities data | <p>List of relevant Milestones:</p> <ol style="list-style-type: none"> 1. Increase in riparian planting |
| Outcome data | Riparian planting and fencing data |
| Metadata | Farm location and number and extent of waterways and water bodies on farm |
| External data | <p>Aerial photography datasets showing extent of riparian foliage on farm</p> <p>Risk rating of catchment in terms of waterway quality</p> |
| Analysis requirements | <p>Matching/mapping aerial photography data onto farm map</p> <p>Data visualisation of extent and rate of planting</p> <p>Analysis of photography to determine planting success</p> <p>Data visualisation of planting success</p> |
| Scale | Single Pledge, immediate |
| Target purchaser | National government |
| Claim type | Recurring |
| Claim potential | <p>Farms in Aotearoa have nearly 200,000 km of waterways running through them. Nitrate and <i>E. coli</i>. median concentrations in waterways are 11 and 18 times higher respectively in farmland compared to areas of native forest cover. Fencing of waterways and planting of appropriately wide riparian strips (10m or more) can reduce runoff of nutrients, effluent, and soil into waterways by up to 90%, improving water quality and protecting native biodiversity.</p> |
| Associated Claims | Above-ground carbon Claims |

| | |
|----------------------|---|
| Claim context | <p>Waterways in Aotearoa are badly polluted by excess nutrients, soil, and sometimes heavy metals [12]. Nitrate and <i>E. coli</i> median concentrations in waterways are 11 and 18 times higher respectively in farmland compared to areas of native forest cover [9]. Planting riparian vegetation strips of at least 10m width either side of waterways on farms on Aotearoa reduces runoff of nutrients, effluent, and soil into waterways [13]. It does this by providing a buffer zone for nutrients to be recycled by natural processes and reducing mechanical deposition of soil. In addition, native freshwater ecosystems in Aotearoa are adapted to shaded forest conditions [14], so planting appropriately wide riparian strips allows the ecosystem to regenerate.</p> <p>Current regulatory requirements are for riparian buffer strips of 3m on either side of waterways wider than 1m, but do not require riparian planting [15]. This Claim demonstrates that Pledge Holders are going above and beyond the regulatory requirement, by planting as well as fencing, and by how much.</p> |
|----------------------|---|

Drought and Flood Resilience Claim

| | |
|------------------------------|--|
| Claim title | Drought and Flood Resilience Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has improved the resiliency of the land they manage and their farm operations to drought and flood conditions by improving soil water retention capacity, restoring natural wetland areas, and reducing reliance on irrigation. Claim that Pledge Holder has improved water retention in soils, making the farm more resilient to both drought and flood conditions. The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none"> 1. Soil water retention data 2. Water use data 3. Wetland restoration data 4. Third-party datasets on weather and drought/flood events 5. Metadata contextualising farm location & success |
| Activities data | <p>List of relevant milestones:</p> <ol style="list-style-type: none"> 1. Restoration of wetlands 2. Increase in planting on riparian 3. Non-riparian planting 4. Decrease irrigation 5. Complete an annual soil test 6. Grazing management 7. Pasture species |
| Outcome data | <ul style="list-style-type: none"> • Soil water interaction capacity dataset (how much water can soil hold?) • Water use data (How much does the farm rely on irrigation?) • Wetland restoration data AND/OR • Riparian planting data • Non-riparian planting data (How much of the farm's wetland area has been restored, and how much land has been retired?) |
| Metadata | <ul style="list-style-type: none"> • Farm location data • dates and locations of included datasets • Stock numbers • Ephemeral and perennial waterways • Water use data if not separate milestone |
| External data | <ul style="list-style-type: none"> • Remote sensing soil moisture data • historical and current weather records • historical and current flood and drought events |
| Analysis requirements | <ul style="list-style-type: none"> • Geolocation of data (Pledge and external) onto farm • graphing of changes in water use/soil water capacity • statistical analysis of flood/drought event impact and lowering of impact over time |
| Scale | One Pledge, starting from 2-5 years in |
| Target purchaser | Banks holding farm mortgages, insurers |
| Claim type | Recurring |

Claim potential Drought and flood events in Aotearoa currently cause tens of millions of dollars per event in insured damage (floods) and billions of dollars per event in economic losses (droughts). They are forecast to increase in frequency as a result of climate change (see 'Claim context'). Soil improvements, riparian and non-riparian planting, and restoration of wetlands could reduce these losses depending on the extent of farms which take them up.

Associated Claims Protecting the Water Cycle Claim (bundled towards)

Claim context Droughts and floods are both a result of the water cycle not functioning in a consistent way [19]. When soil is permeable to water, it retains moisture and plants can survive longer periods without precipitation [20]. When it is impermeable or less permeable, plants are less resilient to periods of low rainfall, and high rainfall causes water to pool and flood. This can cause property damage and inhibit plant growth. Climate change is forecast to increase rainfall in some areas of Aotearoa and lessen it in others, as well as making it less consistent. This is expected to increase the number and severity of both floods and droughts [21]. Farms can become more resilient to floods and drought by improving their soil quality and its ability to absorb and retain water [20], as well as in some cases by retiring pastoral land and low-lying areas to forest and wetland [22]. This reduces flooding in periods of high rainfall, and increases pasture resilience in periods of low rainfall.

Pasture Biodiversity & Soil Health Claim

| | |
|------------------------------|--|
| Claim title | Pasture Biodiversity & Soil Health Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has increased the biodiversity of farm pastures, above and below ground. The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none"> 1. Pasture biodiversity dataset (Pledge Holders will need to gather data on most paddocks to make this Claim) 2. Optional soil health datasets |
| Activities data | <ol style="list-style-type: none"> 1. Pasture biodiversity (seeding) 2. Soil tests 3. Decrease in synthetic fertiliser 4. Decrease in pesticides |
| Outcome data | <ul style="list-style-type: none"> • Pasture biodiversity (averages and improvement) • Soil health/biodiversity (rhizosheaths, worms, rooting depths) • Soil organic matter |
| Metadata | <ul style="list-style-type: none"> • Farm location • Farm size • Number of paddocks • Stock types |
| External data | No external data is required for this Claim. |
| Analysis requirements | <p>Pasture biodiversity will need to be analysed to show change over time (neither number of species nor percentage of species individually is sufficient to compare diversity; there are specialist metrics that should be identified by an ecologist as appropriate). Soil health trends should be graphed over time but direct metrics should be sufficient.</p> |
| Scale | Single Pledge, 2-10 years |
| Target purchaser | Green investors |
| Claim type | Recurring |
| Claim potential | <p>There are approximately 2,400,000 Ha of pastoral dairy land in Aotearoa, which is suitable for multispecies pastures. Conventional dairy pastures currently use more than 280,000 tonnes of nitrogen per year. Switching to multispecies pasture can improve soil health and quality, and maintain productivity while reducing synthetic nitrogen fertiliser use and nitrogen leaching.</p> |
| Associated Claims | SAFI, Regenerative Organic Standard |

| | |
|----------------------|---|
| Claim context | <p>Conventional dairy production in Aotearoa relies primarily on ryegrass/clover perennial pasture fertilised with synthetic nitrogen fertilisers [10]. This can support very high stocking rates and levels of milk production, but also leads to damaging environmental impacts, particularly in terms of pollution of waterways [9], [23].</p> <p>This Claim demonstrates that a Pledge Holder has created and is maintaining multispecies pastures of at least 9 species including a functionally diverse range of grasses, legumes, and forbs [24]. Multispecies pastures have been shown to maintain and improve forage production and nutrition, and milk production [25], [26], while mitigating environmental damage by lowering urinary nitrogen which leads to a decrease in nitrogen leaching [27].</p> |
|----------------------|---|

Pollution Reduction Claim

| | |
|------------------------------|--|
| Claim title | Pollution Reduction Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has reduced overall farm pollution, including air pollution, soil pollution, and water pollution. It will show that the Pledge Holder is either not emitting/producing pollutants, or they are recycling or reusing them in an environmentally responsible way.</p> <p>The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none"> 1. Burn-off datasets 2. Organic waste datasets (including offal management if relevant) 3. Recycling practices dataset 4. Fertiliser and pesticide use datasets 5. Water quality/runoff datasets 6. (imported feed for balage if no recyclable alternative) |
| Activities data | <p>List of relevant Milestones:</p> <ol style="list-style-type: none"> 1. Decrease burn-offs 2. Increase waste recycling 3. Reuse organic waste 4. Decrease synthetic fertiliser 5. Decrease pesticides 6. Conduct water sampling 7. Conduct soil sampling |
| Outcome data | <ul style="list-style-type: none"> • Waste production data for organic and other waste • Usage data for common environmental pollutants (fertilisers, pesticides) • Frequency of burn-offs • Soil and water sampling for pollutants • If direct usage data is not available some data may have to be used as a proxy - e.g. imported feed data as a proxy for plastic waste from imported feed packaging |
| Metadata | <ul style="list-style-type: none"> • Farm location • Waterways on farm |
| External data | <ul style="list-style-type: none"> • Catchment area pollution data • Air pollution data for local area |
| Analysis requirements | <p>Analysis required will include:</p> <ul style="list-style-type: none"> • Location of farm relative to catchment and urban areas • Nutrient runoff analysis/prediction • Total waste amounts |
| Scale | Single Pledge, 1-5 years |
| Target purchaser | Local government, supply chain |
| Claim type | Recurring |
| Claim potential | Farms in Aotearoa, like any other industry, produce multiple waste streams which create soil, water, and air pollution [28]–[30]. This Claim commits farms to tracking and minimising waste and its improper disposal. |
| Associated Claims | SAFI |

Claim context

Although they primarily deal in biological production, farms are as capable as any other industry of creating pollution which makes their production less sustainable and negatively impacts the environment.

Waste production primarily falls into these streams [29]:

- **Organic waste:** waste from food, wood, and fibre which can be composted or recycled back to soil], or create air pollution (if burned) or emit greenhouse gases (if buried and subject to natural anaerobic decomposition).
- **Plastic waste:** Waste from packaging of inputs brought on-farm, or packaging of farm products. This can sometimes be recycled but is most often buried or burned. Burning emits carbon; burial leads to microplastic pollution of soils.
- **Metal and glass waste:** Waste from farm equipment and packaging of inputs. If not recycled, this can only be buried].
- **Hazardous waste:** Waste such as agrochemicals and batteries. These can contaminate the environment if improperly stored or disposed of.

Local studies in Aotearoa show that most farm waste is not disposed of in a sustainable way [30]. This Claim demonstrates that Pledge Holders are (in order of priority) reducing, re-using, and recycling their waste - the top three sustainable methods of dealing with waste.

Climate Risk Claim

| | |
|------------------------------|---|
| Claim title | Climate Risk Claim |
| Claim description | <p>This is a Climate Risk Report derived from a regenerative agriculture model that supports climate adaptation and mitigation activities on dairy farms in Aotearoa New Zealand.</p> <p>This report provides visibility to the resilience of farmers investing in climate adaptation and mitigation activities, and gives access to the following datasets:</p> <ol style="list-style-type: none"> 1. Relevant metadata to contextualise the farm; 2. Climate adaptation and mitigation management actions undertaken; 3. Key financial and wellbeing performance indicators; 4. Climate adaptation and mitigation investment across key farm working expense categories; 5. Summary view of public datasets that support contextual data analysis. |
| Activities data | <p>List of relevant milestones:</p> <ol style="list-style-type: none"> 1. Decrease synthetic fertiliser use 2. Increase pasture species diversity 3. Change from conventional grazing practices 4. Decrease in chemical pesticides (insecticide, herbicide, fungicide) use 5. Change in conventional tillage frequency 6. Increase in native riparian planting |
| Outcome data | Financial indicators (operating profits and milk solids), wellbeing indicators (milk urea & somatic cell counts), farm expense data on climate mitigation activities |
| Metadata | Farm location data; dates covered by included datapoints/datasets; stock numbers |
| External data | Climate predictions for region |
| Analysis requirements | Farm operating profits, assigning expense data to categories |
| Scale | One Pledge, immediately |
| Target purchaser | Banks holding farm mortgages, insurers |
| Claim type | Recurring |
| Claim potential | These data permit banks to fulfill their obligations to disclose climate-related risk in their portfolios. There is currently nearly NZ\$63 billion of agricultural debt in Aotearoa . This represents a significant disclosure burden for banks which can be met through this Claim. |
| Associated Claims | SAFI, TCFD |
| Claim context | This is a financial Claim oriented around bank disclosure requirements. It is intended to meet the requirements set by the Task Force on Climate-Related Financial Disclosures [1]. The operating expense categories it uses are based on those set out by DairyNZ, the industry organisation for dairy farmers in Aotearoa [2]. The productivity and animal wellbeing indicators chosen (milk solids [3], milk urea [4], and somatic cell counts [5]) are established industry metrics. |

Limited Nitrogen Input Claim

| | |
|------------------------------|---|
| Claim title | Limited Nitrogen Input Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has reduced total nitrogen inputs (external to nitrogen fixation by plants) and eliminated synthetic nitrogen inputs.</p> <p>The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none"> 1. Farm location and size metadata 2. Nitrogen-containing fertiliser and fertility product application data |
| Activities data | <p>List of relevant milestones:</p> <ol style="list-style-type: none"> 1. Decrease synthetic fertiliser |
| Outcome data | N-containing fertiliser and fertility product dataset (application rates of synthetic and organic N-containing fertiliser) |
| Metadata | <ol style="list-style-type: none"> 1. Farm location 2. Farm size 3. Farm effective production platform |
| External data | None |
| Analysis requirements | Application rates of nitrogen will need to be calculated for some organic products (e.g. compost). |
| Scale | Single Pledge, immediately |
| Target purchaser | Local or national government |
| Claim type | Recurring |
| Claim potential | The amount of nitrogen applied to farm soils in Aotearoa has increased 629% since 1990 (as of 2019)[6] . In 2019, 452,000 tonnes of nitrogen was applied in fertilisers. Dairy farms apply 63% of nitrogen fertiliser [7], so reducing synthetic nitrogen use on dairy farms has the potential to reduce nitrogen fertiliser use by over 250,000 tonnes annually. |
| Associated Claims | SAFI standard, water quality |
| Claim context | Excess nitrogen from agricultural land is lost as nitrate into groundwater and waterways, and nitrous dioxide into the atmosphere. Nitrate in water contributes to eutrophication and, in high concentrations, low-oxygen 'dead-zones'; nitrous oxide is a potent greenhouse gas. Reducing nitrogen loss and minimising excess nitrogen application is a major issue for agriculture globally [8], [9]. In pastoral farming, nitrogen fertilisers are used to maximise pasture growth and therefore the stocking rate of dairy cows. Pasture which relies on natural nitrogen fixation by plants is more nitrogen efficient and has lower losses [10]. Application of natural nitrogen fertilisers can also result in nitrogen loss depending on the conditions under which it is used [11]. Therefore, this Claim provides data on all sources of nitrogen to show that it has been reduced overall and synthetic nitrogen fertilisers have been eliminated. |

Emission Reduction Claim

| | |
|------------------------------|--|
| Claim title | Emission Reduction Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder is reducing their overall on-farm greenhouse gas emissions.</p> <p>The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none">1. Stock numbers2. Nitrogen application totals dataset3. Decarbonisation dataset4. Burn-off dataset5. Carbon emissions analysis report |
| Activities data | <p>List of relevant Milestones:</p> <ol style="list-style-type: none">1. Decrease synthetic fertiliser2. Decrease stock numbers3. Decarbonise on-farm operations4. Reduce burn-offs5. Carbon emissions analysis |
| Outcome data | <ol style="list-style-type: none">1. Carbon emissions analysis results2. Supporting data for emissions analysis (i.e. stock numbers, petrol use, burn-offs) |
| Metadata | Size of farm (land area, stock numbers) |
| External data | No external data is required for this Claim. |
| Analysis requirements | One of the Milestones required is a third-party carbon emissions analysis report. If this does not break down emissions by source, this will also need to be estimated. |
| Scale | Single Pledge, immediate |
| Target purchaser | Carbon market(s) |
| Claim type | One-off |
| Claim potential | Implementing these activities could reduce on-farm greenhouse gas emissions by up to 20% depending on which Milestones Pledge Holders have chosen. |
| Associated Claims | This may exclude other carbon Claims depending on their nature. |
| Claim context | Total agricultural greenhouse gas emissions amount to 48% of all greenhouse gas emissions in Aotearoa [16]. Transportation (i.e. use of internal combustion engines) is the second largest source of emissions [17]. The activities outlined here - decreasing fertiliser use, decreasing burn-offs, decreasing stock numbers, and decarbonising other on-farm operations - should result in significant (up to 20%) emissions decreases, based on existing predictions [18] which will be documented by a third-party analysis. |

Erosion Risk Reduction Claim

| | |
|--------------------------|--|
| Claim title | Erosion Risk Reduction Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has improved soil health and quality, and returned some erosion-prone land to forest rather than pasture. In doing these things, they will have lowered the overall risk of erosion on their land. Soil with high organic matter content and plant integration does not easily wash away, and forest cover on steeper sections also helps prevent washouts and landslips.</p> <p>The Milestones which will contribute to this Claim are riparian planting, non-riparian planting, soil sampling, improving pasture diversity, and improving grazing management.</p> <p>This Claim is specifically intended to relate to soil improvement and planting on regenerative agricultural farms. A different and more specific erosion Claim will be created for farms which are only making a native reforestation/biodiversity Pledge.</p> <p>It will include datasets on riparian and non-riparian planting, soil health and quality, farm location and usage, pasture diversity and grazing management changes, and external metadata on farm terrain and erosion risk.</p> |

Circular Farm Economy Claim

| | |
|--------------------------|---|
| Claim title | Circular Farm Economy Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder is tracking and minimising farm waste streams, and recycling where possible. Unlike the pollution reduction Claim it is focused on on-farm reuse and recycling, including of products that are not necessarily considered 'waste'.</p> <p>The Milestones related to this Claim will include reusing organic waste, integrating farm activities, and increasing waste recycling.</p> <p>It will include datasets on waste fate; on processes which reuse or recycle waste and other farm produce on-farm; on supplementary feed growth; and on the integration of farm activities, e.g. use of manure from livestock for vegetable growth.</p> |

Reduced Runoff Claim

| | |
|--------------------------|---|
| Claim title | Reduced Runoff Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has reduced runoff from their land. In this context, 'runoff' means excess fertiliser (nitrogen and phosphate), pesticides, and soil erosion, carried by water through and along soil into local waterways. It can be used as a first step towards a Drought & Flood Resilience Claim, as part of being resilient to drought and flood is having low levels of runoff as healthier soil absorbs and retains water, and excess products are not applied.</p> <p>The Milestones which will contribute to this Claim are decreasing synthetic fertilisers, grazing management, increasing pasture biodiversity, and monitoring soil health.</p> <p>It will include data on inputs (fertilisers and pesticides), water quality (turbidity, nutrients), and soil response to water. It will not report on riparian planting, wetland restoration, or include third-party datasets on drought and flood events.</p> |

Stock Reduction Claim

| | |
|--------------------------|---|
| Claim title | Stock Reduction Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has reduced their stocking rate. It will be linked to a Farm Financial Resilience Claim, as it is necessary to demonstrate to banks that farmers can maintain profits and be financially resilient before banks will be comfortable with decreasing stocking rates (which have traditionally been directly linked to profitability).</p> <p>The Milestone which will contribute to this Claim is decreasing stock numbers.</p> <p>It will include abbreviated data on financial performance, and datasets on stock numbers, productivity, and how they relate to farm land usage.</p> |

Soil Carbon Maintenance Claim

| | |
|--------------------------|--|
| Claim title | Soil Carbon Maintenance Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder is acting in a way which will maintain soil carbon levels and soil, rather than losing carbon through soil erosion and degradation. This will be done through grazing maintenance, pasture biodiversity improvement, and improved use of tillage and synthetic fertilisers.</p> <p>The Milestones which will contribute to this Claim are improving pasture biodiversity, improving tillage, soil sampling, improving pasture diversity, and improving grazing management.</p> <p>This Claim is specifically intended to relate to soil improvement and planting on regenerative agricultural farms. A different and more specific soil carbon maintenance Claim will be created for farms which are only making a native reforestation/biodiversity Pledge.</p> <p>It will include datasets on soil health and quality, tillage activity, farm location and usage, pasture diversity and grazing management changes, and external metadata on farm erosion risk and historical soil loss.</p> |

Farm Financial Resilience Claim

| | |
|--------------------------|---|
| Claim title | Farm Financial Resilience Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has made their farm more financially resilient while maintaining profitability. This Claim builds upon the Climate Risk Claim by showing that a farm's profitability has been maintained while its profit centres have been diversified, and that it is less exposed to sudden changes in markets for single products.</p> <p>The Milestones which will contribute to this Claim are reporting on-farm results, integrating and diversifying farm activities, and all Milestones which decrease inputs (e.g. decreasing fertiliser, decreasing pesticides, decarbonising farm operations).</p> <p>It will include datasets on farm financial performance and variance in the financial performance of different activities on the farm over time.</p> |

Future Claims - summary table

None of these Claims can be supported by the existing Catalyst Framework, but are goals to be built towards. Claims **in bold** are outlined in detail.

| Claim | Description | Scale | Purchaser(s) | Can be bundled towards... | Data missing |
|--|---|--|------------------------------------|---------------------------|---|
| Improved Freshwater Quality Claim | Claim that Pledge Holders (as a group) are improving freshwater quality by reducing runoff and increasing biodiversity in freshwater in their catchment | Multiple Pledge(s), 5-10 years+ | Biodiversity market(s), government | SAFI | Sensor-based water quality measurements, freshwater biodiversity measurements |
| Increased Above-Ground Carbon Claim | Claim that Pledge Holder has sequestered carbon above-ground in trees or other vegetation | Single or multiple Pledge(s), 2 years+ | Carbon market(s) | N/A | Native tree sequestration data, remote assessment of carbon stocks |
| Increased Soil Carbon Claim | Claim that Pledge Holder has sequestered carbon in soil | Single Pledge, 5 years+ | Carbon market(s) | N/A | Soil carbon modelling from satellite data; direct soil carbon measurements at high frequency |
| Protecting the Water Cycle Claim | Claim that Pledge Holder(s) is/are protecting the water cycle by improving soil water retention, decreasing water uptake, and reducing flood and drought events on their land | Single or multiple Pledge(s), 3 years+ | Government | SAFI | Sensor-based water quality measurements; groundwater quality measurements; weather records; flood and drought records |
| Sustainable Agriculture Finance Initiative Claim | Claim that Pledge Holder is meeting the Sustainable Agriculture Finance Initiative (SAFI) standard, such that their debt can be used in a green bond | Single Pledge, 5 years+ | Banks | Is a bundle | Risk assessment, worker wellbeing, animal wellbeing, aerial photography, biodiversity [Farm Reforestation] and stream biodiversity milestones |
| Regenerative Organic Standard Claim | Claim that Pledge Holder is meeting a Regenerative Organic standard and their produce can be sold as such by companies they are supplying | Single Pledge, 5 years+ | Supply chain | Is a bundle | Invasive species control and endangered species protection measures (Native Reforestation), ban on GMOs including RNAi, use of COMET or similar model, animal and worker wellbeing measures. NOTE: this is based on the American ROC standard; it would need to be adapted for farms in Aotearoa. |

Improved Freshwater Quality Claim

| | | | |
|------------------------------|--|--------------------------|--|
| Claim title | Improved Freshwater Quality Claim | Claim potential | Freshwater in Aotearoa has been severely impacted by runoff from intensive farming, leading to 95% of river length in pastoral areas showing decreases in water quality and/or biodiversity [9]. While this situation has taken years to occur and will take years to fix, this Claim has the potential to demonstrate improvement across the approximately 200,000 km of waterways situated on pastoral farms. |
| Claim description | <p>This Claim demonstrates that a group of Pledge Holders have contributed to the restoration of a freshwater catchment. As a result of their actions, the water quality and biodiversity of the catchment as a whole and its main waterway have improved.</p> <p>The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none"> 1. Nitrogen and phosphorus input data 2. Soil runoff data 3. Riparian planting data 4. Wetland restoration data 5. Water quality data (sensors) 6. Water quality data (biodiversity) | Associated Claims | Follows on from 'Reduced Runoff' Claim, bundles into SAFI Claim and Protecting the Water Cycle Claim |
| Activities data | <p>List of relevant Milestones:</p> <ol style="list-style-type: none"> 1. Decrease in synthetic fertilisers 2. Decrease in pesticides 3. Grazing management 4. Increase in pasture biodiversity 5. Increase in riparian planting 6. Restoration of wetlands | Claim context | <p>Negative impacts on freshwater from farming activity can be primarily sorted into three categories [23, p. 202]:</p> <ul style="list-style-type: none"> ● Nutrients: excess nutrients (nitrogen and phosphorus) make waterways eutrophic, leading to lowered oxygen levels, overgrowth of phototrophs, and reduced biodiversity. ● Soil: Soil runoff leads to loss of carbon and topsoil on land, and impacts negatively on biodiversity in waterways. ● Effluent: Faeces from livestock, aside from carrying excess nutrients, can contaminate waterways with pathogenic bacteria, making water unsuitable for human use]. <p>This Claim demonstrates that a group of Pledge Holders have come together to reduce these three major types of runoff/pollution (measured directly), and to create 'buffer zones' with riparian planting and wetland restoration which both limit direct stock access to waterways and allow natural breakdown of nutrients/effluent [13], [31], [32]. As a result, the water quality - in terms of both physicochemical properties and biodiversity - in a specific catchment has improved.</p> |
| Outcome data | <ul style="list-style-type: none"> ● Damaging water inputs (nitrogen, phosphorus, pesticides) ● Extent of wetland restoration (%age of wetlands) ● Extent of riparian planting (%age of waterways, to what width) ● Water quality data - Pledge Holder + laboratory tests (turbidity, nutrients) ● Water quality data - sensor networks (turbidity, nutrients, oxygen) ● Water quality data - biodiversity assessments | | |
| Metadata | <ul style="list-style-type: none"> ● Farm location and extent ● Perennial waterways on farm ● Percentage of riparian planting as a total of waterway length ● Percentage of wetland restoration | | |
| External data | <ul style="list-style-type: none"> ● Water quality data from catchment outside participating farms - e.g. council water quality data | | |
| Analysis requirements | <ul style="list-style-type: none"> ● Location/relationship of individual farms to catchment ● Analysis of average water quality across multiple Pledges/whole catchment ● Analysis of actions taken across multiple Pledges (e.g. average planted waterways) ● Analysis of links between biodiversity and water quality | | |
| Scale | Collective (multiple Pledges), 5-10 years+ | | |
| Target purchaser | Government, insurance | | |
| Claim type | Recurring | | |

Increased Above-Ground Carbon Claim

| | |
|------------------------------|--|
| Claim title | Increased Above-Ground Carbon Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has sequestered carbon above ground in forest and other above-ground biomass.</p> <p>The Claim purchaser will gain visibility to datasets including:</p> <ol style="list-style-type: none"> 1. Total planting of trees 2. Land use/retirement 3. Herbicide use 4. Wetland restoration |
| Activities data | <p>List of relevant Milestones:</p> <ol style="list-style-type: none"> 1. Increase in riparian planting 2. Increase in non-riparian planting 3. Restoration of wetlands 4. Decrease in pesticides |
| Outcome data | <ul style="list-style-type: none"> • Area planted in trees and retired • Wetland area restored • Absence of herbicide use |
| Metadata | <ul style="list-style-type: none"> • Farm location |
| External data | Aerial photography and/or satellite photography showing extent of planting |
| Analysis requirements | Compare aerial photography to planting records, amount of carbon sequestered in these patches of forest and/or wetlands under these conditions |
| Scale | Single Pledge, 2 years+ |
| Target purchaser | Carbon market(s) |
| Claim type | Recurring |
| Claim potential | Pastoral farms in Aotearoa occupy over 50% of the total land area and host nearly 20% of remaining native vegetation [33]. Retiring into forest or engaging in agroforestry [34] only an additional 10% of this area would equate to a permanent carbon stock nearly as large as the current extent of plantation forestry (8% of land area [23]). Assuming native planting and the current stocks estimated in the ETS [35] it could sequester up to 430 Mt of carbon. |
| Associated Claims | Other carbon claims are excluded (e.g. Improved Carbon, Biodiversity including Carbon) |
| Claim context | Healthy native forest in Aotearoa provides a biodiverse habitat and sequesters significant amounts of carbon in trees and undergrowth - if permanent, more over the long term than <i>Pinus radiata</i> plantations, as trees are longer-lived [36]. Wetlands can also sequester significant amounts of carbon in vegetation and soils [37]. This Claim is essentially a carbon offset showing that a Pledge Holder has conducted planting and maintenance which will lead to carbon storage on land which has either been retired from pastoral use (i.e. wetlands and permanent native forest), or is now mixed-use agroforestry, sequestering less carbon in vegetation but permitting pastoral farming to continue [38]. |

Increased Soil Carbon Claim

| | |
|------------------------------|--|
| Claim title | Increased Soil Carbon Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has increased the amount of carbon sequestered in soils on their land, and continues to manage it in a way which will maintain this sequestration. It builds on the Soil Carbon Maintenance Claim.</p> <p>The Claim purchaser will gain visibility to:</p> <ol style="list-style-type: none"> 1. Direct data on soil carbon 2. Indirect indicators of soil carbon 3. Activities data showing management 4. Metadata on farm location and land type |
| Activities data | <p>List of relevant Milestones:</p> <ol style="list-style-type: none"> 1. Collect soil samples 2. Increase in pasture biodiversity 3. Grazing management 4. Record tillage management |
| Outcome data | <ul style="list-style-type: none"> • Soil carbon measurements and metadata • General soil quality data • Tillage data • Grazing management overview • Pasture biodiversity overview |
| Metadata | <ul style="list-style-type: none"> • Farm location • Farm land use • Soil types (from external database) |
| External data | Any remote sensing data which can validate soil carbon |
| Analysis requirements | Analysis of remote sensing data and/or any other proxy measures for soil carbon which are developed. |
| Scale | Single Pledge, 5-10 years from now |
| Target purchaser | Carbon market(s) |
| Claim type | Recurring |
| Claim potential | Pastoral soils in New Zealand have been forecast to be able to sequester up to 124 Mt of carbon [39]. |
| Associated Claims | Excludes any other soil carbon Claims |
| Claim context | Significant amounts of carbon are sequestered in soils globally. It has been demonstrated on other continents that agricultural soils can sequester more carbon than they currently hold, depending on land management practices [40], [41]. It is generally thought that soils in Aotearoa have less potential to sequester additional carbon, as they have relatively high carbon concentrations already [42]. However, pastoral soils in Aotearoa may still be able to sequester up to 124Mt of carbon [39]. |

Protecting the Water Cycle Claim

| | |
|--------------------------|--|
| Claim title | Protecting the Water Cycle Claim |
| Claim description | <p>This Claim demonstrates that one or more Pledge Holder(s) is/are protecting the water cycle on their land by improving soil water retention, decreasing water uptake, and reducing flood and drought events on their land. As a result, perennial waterways are healthier, wetlands have been restored in areas where they naturally exist, and groundwater is being maintained or replenished. This Claim builds on Reduced Runoff, Improving Drought & Flood Resilience, and Improving Freshwater Quality Claims, and may ultimately be additional to them.</p> <p>The Milestones which will contribute to this Claim are conducting water sampling, grazing management, increasing pasture biodiversity, decreasing irrigation, decreasing fertilisers and pesticides, restoration of wetlands, and increasing riparian planting.</p> <p>It will include data on water quality, retiring and/or fencing off of riparian areas and wetlands, ephemeral and perennial waterways, soil quality and water infiltration. External datasets on groundwater quality, sensor-based water quality, and flood and drought records will also be needed.</p> |

Regenerative Organic Standard Claim

| | |
|--------------------------|---|
| Claim title | Regenerative Organic Standard Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has met the requirements of a Regenerative Organic 'gold standard'. Currently this is imagined to be something similar to the Regenerative Organic Certification being developed in North America, but a specific Certification would have to be adapted for the Aotearoa context.</p> <p>The Milestones which would contribute to this Claim are very similar to the SAFI Milestones but would include more data on regenerative activities, such as integrating farm activities or decreasing tillage.</p> <p>Like a SAFI Claim, this would be a 'bundled' Claim where purchasers are gaining visibility to an assessment that the bundled Claims meet the standard, plus any data not included in the bundled Claims. They would not necessarily gain direct access to data from the bundled Claims unless they were purchased as well.</p> <p>Development of this Claim will probably require alignment with an external body interested in developing a Regenerative Organic Certification for Aotearoa.</p> |

Sustainable Agriculture Finance Initiative Claim

| | |
|--------------------------|---|
| Claim title | Sustainable Agriculture Finance Initiative Claim |
| Claim description | <p>This Claim demonstrates that a Pledge Holder has met the standards of the Sustainable Agriculture Finance Initiative and debt on their properties qualifies for green bonds. It will be a 'bundle' of many other Claims including most Milestones within the existing Catalyst Framework. The SAFI Claim itself will likely represent an assertion that a Venture or other entity has checked the Pledge Holder's bundle of Claims against SAFI and found it to meet the standard. The purchaser of a SAFI Claim would still have to purchase the bundled Claims as well to access those datasets.</p> <p>The Milestones which will contribute to this Claim are all Milestones regarding inputs, activity which emits carbon, soil and water testing, waste management, activities which sequester carbon, and additional Milestones yet to be developed around worker and animal welfare, as well as, most likely, some biodiversity Milestones from the Native Reforestation market.</p> <p>The Claim purchaser will gain visibility to an assessment showing the bundled Claims meet the SAFI standard, plus direct datasets from any additional Milestones which are required for the SAFI standard and not included in bundled Claims.</p> |

Claim gaps

A number of Claims which it is possible for us to forecast have 'gaps' - i.e., measurements which must be made in order to substantiate the Claim, but which our current Catalyst Framework does not include.

Some of these gaps are due to missing pieces in the market economy surrounding Claims. The technical knowledge which is needed to make the measurements exists, but we do not yet know how to connect Pledge Holders with this technical knowledge in a scalable way.

Other gaps are true 'knowledge gaps'. This is when the technical and/or scientific understanding to make these measurements in a scalable way either does not exist, or has not been validated in an Aotearoa context. For example, there are a number of methodologies currently in development to measure soil carbon levels using remote sensing techniques, but none have been validated on soils in Aotearoa [43].

Below, we identify a number of gaps which exist in this Claim Forecast and specify whether they are due to knowledge gaps or market gaps. The next document in the Regenerative Agriculture Science Opportunity Forecast is the Regenerative Agriculture Knowledge Gaps document. It identifies in more detail the indicators which are 'knowledge gaps' and which Toha wants to promote or partner in research to close, in order to improve and prove regenerative agriculture Claims.

| Missing indicators | Type of gap |
|---|--------------------|
| Aerial photography | Market |
| Remote soil moisture sensing | Knowledge |
| Water sensors (pollution, oxygen, turbidity) | Market |
| Remote soil carbon measurements | Knowledge |
| Freshwater biodiversity pesticide sensitivity | Knowledge |
| Pasture biodiversity remote sensing | Knowledge |
| Hydrology mapping | Knowledge |
| Soil health sensors (physicochemical & biological) | Knowledge |
| Correlating soil microbiology & soil quality | Knowledge |
| Appropriate multispecies pastures by location in Aotearoa | Knowledge |
| Local air quality measurements | Market |
| Cattle methane emissions on multispecies pasture | Knowledge |

Bibliography

- [1] 'Recommendations of the Task Force on Climate-Related Financial Disclosures', Task Force on Climate-Related Financial Disclosures, Jun. 2017.
- [2] DairyNZ, 'DairyNZ Economic Survey 2017-18'. DairyNZ, May 2019.
- [3] C. B. Glassey, 'Development and testing of new performance measures for milksolids production per hectare', *Proc. N. Z. Grassl. Assoc.*, pp. 253–257, Jan. 2007, doi: 10.33584/jnzc.2007.69.2670.
- [4] J. M. Powell, C. A. Rotz, and M. A. Wattiaux, 'Potential use of milk urea nitrogen to abate atmospheric nitrogen emissions from Wisconsin dairy farms', *J. Environ. Qual.*, vol. 43, no. 4, pp. 1169–1175, 2014.
- [5] Y. H. Schukken, D. J. Wilson, F. Welcome, L. Garrison-Tikofsky, and R. N. Gonzalez, 'Monitoring udder health and milk quality using somatic cell counts', *Vet. Res.*, vol. 34, no. 5, pp. 579–596, 2003.
- [6] Stats NZ, 'Fertilisers - nitrogen and phosphorus', Apr. 15, 2021. <https://www.stats.govt.nz/indicators/fertilisers-nitrogen-and-phosphorus> (accessed Jan. 11, 2022).
- [7] Fertiliser Association, 'Fertiliser use in NZ'. http://www.fertresearch.org.nz/site/about/fertiliser_use_in_nz.aspx (accessed Jan. 11, 2022).
- [8] K. C. Cameron, H. J. Di, and J. L. Moir, 'Nitrogen losses from the soil/plant system: a review', *Ann. Appl. Biol.*, vol. 162, no. 2, pp. 145–173, 2013, doi: <https://doi.org/10.1111/aab.12014>.
- [9] Ministry for the Environment and Stats NZ, 'Our Freshwater 2020', Ministry for the Environment and Stats NZ, 2020. Accessed: Apr. 12, 2021. [Online]. Available: <https://www.mfe.govt.nz/sites/default/files/media/Environmental%20reporting/our-freshwater-2020.pdf>
- [10] S. F. Ledgard, J. W. Penno, and M. S. Sprosen, 'Nitrogen inputs and losses from clover/grass pastures grazed by dairy cows, as affected by nitrogen fertilizer application', *J. Agric. Sci.*, vol. 132, no. 2, pp. 215–225, Mar. 1999, doi: 10.1017/S002185969800625X.
- [11] D. J. Houlbrooke, D. J. Horne, M. J. Hedley, J. A. Hanly, and V. O. Snow, 'A review of literature on the land treatment of farm-dairy effluent in New Zealand and its impact on water quality', *N. Z. J. Agric. Res.*, vol. 47, no. 4, pp. 499–511, Dec. 2004, doi: 10.1080/00288233.2004.9513617.
- [12] S. T. Larned, J. Moores, J. Gadd, B. Baillie, and M. Schallenberg, 'Evidence for the effects of land use on freshwater ecosystems in New Zealand', *N. Z. J. Mar. Freshw. Res.*, vol. 54, no. 3, pp. 551–591, 2019, doi: <https://doi.org/10.1080/00288330.2019.1695634>.
- [13] K. E. Collins, 'Benefits of riparian planting: A case study of lowland streams in the Lake Ellesmere catchment', Lincoln University, 2011.
- [14] M. J. Greenwood, J. S. Harding, D. K. Niyogi, and A. R. McIntosh, 'Improving the effectiveness of riparian management for aquatic invertebrates in a degraded agricultural landscape: stream size and land-use legacies', *J. Appl. Ecol.*, vol. 49, pp. 213–222, Feb. 2012, doi: 10.1111/j.1365-2664.2011.02092.x.
- [15] New Zealand Government, *Resource Management (Stock Exclusion) Regulations 2020*. 2020, p. 12.
- [16] Ministry for the Environment, 'Net emissions and removals from vegetation and soils on sheep and beef farmland', Ministry for the Environment, Wellington, New Zealand, Mar. 2021.
- [17] He Pou a Rangī | Climate Change Commission, '2021 Draft Advice for Consultation', He Pou a Rangī | Climate Change Commission, Wellington, New Zealand, Feb. 2021.
- [18] A. Reisinger, H. Clark, P. Journeaux, D. Clark, and G. Lambert, 'On-farm options to reduce agricultural GHG emissions in New Zealand'. New Zealand Agricultural Greenhouse Gas Research Centre, Jul. 2017.
- [19] R. G. Taylor et al., 'Ground water and climate change', *Nat. Clim. Change*, vol. 3, no. 4, Art. no. 4, Apr. 2013, doi: 10.1038/nclimate1744.
- [20] P. Sullivan, 'Agronomy Technical Note: Drought Resistant Soil'. National Center for Appropriate Technology, Nov. 2002. [Online]. Available: <http://www.attra.ncat.org/attra-pub/PDF/drought.pdf>
- [21] D. Frame, S. Rosier, T. Carey-Smith, L. Harrington, S. Dean, and I. Noy, 'Estimating financial costs of climate change in New Zealand', New Zealand Treasury, Wellington, New Zealand.
- [22] T. R. Marapara, 'Eco-hydrology interactions between trees, soil and water in terrestrial and wetland areas: The effect of tree planting on water flow dynamics in Wairarapa Wetlands, New Zealand', Doctor of Philosophy, Victoria University of Wellington, Wellington, New Zealand, 2016.
- [23] Ministry for the Environment and Stats NZ, 'Our Land 2021', Wellington, New Zealand, 2021.
- [24] S. L. Woodward, C. D. Waugh, C. G. Roach, D. Fynn, and J. Phillips, 'Are diverse species mixtures better pastures for dairy farming?', *Proc. N. Z. Grassl. Assoc.*, vol. 75, pp. 79–84, 2013.
- [25] F. Nobilly, R. H. Bryant, B. A. McKenzie, and G. R. Edwards, 'Productivity of rotationally grazed simple and diverse pasture mixtures under irrigation in Canterbury', *Proc. N. Z. Grassl. Assoc.*, vol. 75, pp. 165–172, 2013.
- [26] K. G. Pembleton, K. N. Tozer, G. R. Edwards, J. L. Jacobs, and L. R. Turner, 'Simple versus diverse pastures: opportunities and challenges in dairy systems', *Anim. Prod. Sci.*, vol. 55, no. 7, pp. 893–901, 2015.
- [27] P. C. Beukes et al., 'The potential of diverse pastures to reduce nitrogen leaching on New Zealand dairy farms', *Anim. Prod. Sci.*, vol. 54, no. 12, pp. 1971–1979, 2014.
- [28] K. M. Bayne, V. R. Clifford, B. R. Baillie, and H. G. Pearce, 'Fire as a Land Management Tool: Rural Sector Perceptions of Burn-off Practice in New Zealand', *Rangel. Ecol. Manag.*, vol. 72, no. 3, pp. 523–532, May 2019, doi: 10.1016/j.rama.2018.12.001.
- [29] F. Scott and J. Curtis, 'New Zealand Rural Waste Minimisation Project Completion Report', Environment Canterbury, Jun. 2018.
- [30] J. Matthews, 'Rural Waste Surveys Data Analysis Waikato & Bay of Plenty', GHD Limited, Jul. 2014.
- [31] K. Renouf and J. Harding, 'Characterising riparian buffer zones of an agriculturally modified landscape', *N. Z. J. Mar. Freshw. Res.*, vol. 49, no. 3, pp. 323–332, Jul. 2015, doi: 10.1080/00288330.2015.1013475.
- [32] J. Quinn, 'Effects of rural land use (especially forestry) and riparian management on stream habitat', *NZ J. For.*, vol. 49, no. 4, pp. 16–19, Feb. 2005.
- [33] D. A. Norton, H. L. Buckley, B. S. Case, and J. L. Pannell, 'The New Zealand Beef and Sheep Sector's Contribution to Biodiversity and Carbon Sequestration', *Proceedings*, vol. 8, no. 1, p. 48, Mar. 2019, doi: 10.3390/proceedings2019008048.
- [34] C. Elevitch, D. Mazaroli, and D. Ragone, 'Agroforestry Standards for Regenerative Agriculture', *Sustainability*, vol. 10, no. 9, p. 3337, Sep. 2018, doi: 10.3390/su10093337.
- [35] New Zealand Government, *Climate Change (Forestry Sector) Regulations 2008*. 2008, p. 75.
- [36] R. J. W. Brienen, 'Forest carbon sink neutralized by pervasive growth-lifespan trade-offs', *Nat. Commun.*, vol. 11, no. 4241, p. 10, 2020, doi: <https://doi.org/10.1038/s41467-020-17966-z>.
- [37] V. Meduna, 'New Offset Options for New Zealand', Motu Economic and Public Policy Research, Wellington, New Zealand, 25, 2016.
- [38] C. Elevitch, D. Mazaroli, and D. Ragone, 'Agroforestry Standards for Regenerative Agriculture', *Sustainability*, vol. 10, no. 9, p. 3337, Sep. 2018, doi: 10.3390/su10093337.
- [39] S. R. McNally et al., 'Soil carbon sequestration potential of permanent pasture and continuous cropping soils in New Zealand', *Glob. Change Biol.*, vol. 23, no. 11, pp. 4544–4555, 2017, doi: 10.1111/gcb.13720.

- [40] X. Bai *et al.*, 'Responses of soil carbon sequestration to climate-smart agriculture practices: A meta-analysis', *Glob. Change Biol.*, vol. 25, no. 8, pp. 2591–2606, 2019, doi: 10.1111/gcb.14658.
- [41] D. Whitehead *et al.*, 'Management practices to reduce losses or increase soil carbon stocks in temperate grazed grasslands: New Zealand as a case study', *Agric. Ecosyst. Environ.*, vol. 265, pp. 432–443, 2018.
- [42] K. R. Tate *et al.*, 'Land-use change alters New Zealand's terrestrial carbon budget: uncertainties associated with estimates of soil carbon change between 1990–2000', *Tellus B Chem. Phys. Meteorol.*, vol. 55, no. 2, pp. 364–377, Jan. 2003, doi: 10.3402/tellusb.v55i2.16762.
- [43] T. Angelopoulou, N. Tziolas, A. Balafoutis, G. Zalidis, and D. Bochtis, 'Remote Sensing Techniques for Soil Organic Carbon Estimation: A Review', *Remote Sens.*, vol. 11, no. 6, p. 676, Mar. 2019, doi: 10.3390/rs11060676.



TOHA
Science